Open Geospatial Consortium

Submission Date: 2015-05-12

Approval Date: 2015-06-05

Publication Date: 2015-08-19

External identifier of this OGC® document: http://www.opengis.net/doc/DP/1.0/geopackage-plugfest

Internal reference number of this OGC® document: OGC 15-012r2

Category: OGC® Discussion Paper

Editor: Jeff Yutzler

OGC GeoPackage Plugfest

Discussion Paper

Warning

This document is not an OGC Standard. This document is an OGC Discussion Paper and is therefore not an official position of the OGC membership. It is distributed for review and comment. It is subject to change without notice and may not be referred to as an OGC Standard. Further, an OGC Discussion Paper should not be referenced as required or mandatory technology in procurements.

Document type: OGC® Discussion Paper
Document subtype: not applicable
Document stage: Approved for public release
Document language: English

License Agreement

Permission is hereby granted by the Open Geospatial Consortium, ("Licensor"), free of charge and subject to the terms set forth below, to any person obtaining a copy of this Intellectual Property and any associated documentation, to deal in the Intellectual Property without restriction (except as set forth below), including without limitation the rights to implement, use, copy, modify, merge, publish, distribute, and/or sublicense copies of the Intellectual Property, and to permit persons to whom the Intellectual Property is furnished to do so, provided that all copyright notices on the intellectual property are retained intact and that each person to whom the Intellectual Property is furnished agrees to the terms of this Agreement.

If you modify the Intellectual Property, all copies of the modified Intellectual Property must include, in addition to the above copyright notice, a notice that the Intellectual Property includes modifications that have not been approved or adopted by LICENSOR.

THIS LICENSE IS A COPYRIGHT LICENSE ONLY, AND DOES NOT CONVEY ANY RIGHTS UNDER ANY PATENTS THAT MAY BE IN FORCE ANYWHERE IN THE WORLD.

THE INTELLECTUAL PROPERTY IS PROVIDED "AS IS", WITHOUT WARRANTY OF ANY KIND, EXPRESS OR IMPLIED, INCLUDING BUT NOT LIMITED TO THE WARRANTIES OF MERCHANTABILITY, FITNESS FOR A PARTICULAR PURPOSE, AND NONINFRINGEMENT OF THIRD PARTY RIGHTS. THE COPYRIGHT HOLDER OR HOLDERS INCLUDED IN THIS NOTICE DO NOT WARRANT THAT THE FUNCTIONS CONTAINED IN THE INTELLECTUAL PROPERTY WILL MEET YOUR REQUIREMENTS OR THAT THE OPERATION OF THE INTELLECTUAL PROPERTY WILL BE UNINTERRUPTED OR ERROR FREE. ANY USE OF THE INTELLECTUAL PROPERTY SHALL BE MADE ENTIRELY AT THE USER'S OWN RISK. IN NO EVENT SHALL THE COPYRIGHT HOLDER OR ANY CONTRIBUTOR OF INTELLECTUAL PROPERTY RIGHTS TO THE INTELLECTUAL PROPERTY BE LIABLE FOR ANY CLAIM, OR ANY DIRECT, SPECIAL, INDIRECT OR CONSEQUENTIAL DAMAGES, OR ANY DAMAGES WHATSOEVER RESULTING FROM ANY ALLEGED INFRINGEMENT OR ANY LOSS OF USE, DATA OR PROFITS, WHETHER IN AN ACTION OF CONTRACT, NEGLIGENCE OR UNDER ANY OTHER LEGAL THEORY, ARISING OUT OF OR IN CONNECTION WITH THE IMPLEMENTATION, USE, COMMERCIALIZATION OR PERFORMANCE OF THIS INTELLECTUAL PROPERTY.

This license is effective until terminated. You may terminate it at any time by destroying the Intellectual Property together with all copies in any form. The license will also terminate if you fail to comply with any term or condition of this Agreement. Except as provided in the following sentence, no such termination of this license shall require the termination of any third party end-user sublicense to the Intellectual Property which is in force as of the date of notice of such termination. In addition, should the Intellectual Property, or the operation of the Intellectual Property, infringe, or in LICENSOR's sole opinion be likely to infringe, any patent, copyright, trademark or other right of a third party, you agree that LICENSOR, in its sole discretion, may terminate this license without any compensation or liability to you, your licensees or any other party. You agree upon termination of any kind to destroy or cause to be destroyed the Intellectual Property together with all copies in any form, whether held by you or by any third party.

Except as contained in this notice, the name of LICENSOR or of any other holder of a copyright in all or part of the Intellectual Property shall not be used in advertising or otherwise to promote the sale, use or other dealings in this Intellectual Property without prior written authorization of LICENSOR or such copyright holder. LICENSOR is and shall at all times be the sole entity that may authorize you or any third party to use certification marks, trademarks or other special designations to indicate compliance with any LICENSOR standards or specifications. This Agreement is governed by the laws of the Commonwealth of Massachusetts. The application to this Agreement of the United Nations Convention on Contracts for the International Sale of Goods is hereby expressly excluded. In the event any provision of this Agreement shall be deemed unenforceable, void or invalid, such provision shall be modified so as to make it valid and enforceable, and as so modified the entire Agreement shall remain in full force and effect. No decision, action or inaction by LICENSOR shall be construed to be a waiver of any rights or remedies available to it.

Contents

i. Abstract

This OGC discussion paper presents the results of the GeoPackage Plugfest. In this initiative, participants had the opportunity to evaluate the compliance and interoperability of software that produces and consumes GeoPackages containing tiled raster data.

ii. Keywords

The following are keywords to be used by search engines and document catalogues.

ogcdoc, OGC document, GeoPackage, GPKG, plugfest, interoperability, tiles

iii. Preface

The GeoPackage Encoding Standard defines an open, non-proprietary, platform-independent SQLite container for distribution and direct use of geospatial data, including vector features and tile matrix sets of earth images and raster maps at various scales. OGC members and other non-members are invited to participate in a Plugfest to test the use of the GeoPackage (GPKG) standard as a container for tiled imagery and to produce a shareable GPKG file with tiled imagery content.

Attention is drawn to the possibility that some of the elements of this document may be the subject of patent rights. The Open Geospatial Consortium shall not be held responsible for identifying any or all such patent rights.

Recipients of this document are requested to submit, with their comments, notification of any relevant patent claims or other intellectual property rights of which they may be aware that might be infringed by any implementation of the standard set forth in this document, and to provide supporting documentation.

iv. Submitting organizations

The following organizations submitted this Document to the Open Geospatial Consortium (OGC):

U.S. ARMY GEOSPATIAL CENTER

IMAGE MATTERS LLC

v. Submitters

All questions regarding this submission should be directed to the editor or the submitters:

Name	Affiliation
Jeff Yutzler, Editor	Image Matters LLC
Micah Brachman	RGi, for U.S. Army Geospatial Center

1. Scope

This OGC Discussion Paper documents the OGC GeoPackage Plugfest for tiled raster data.

The goal of this Plugfest was to determine the following:

- Whether providers produce compliant GeoPackages containing tiled raster data
- Whether clients behave as expected after loading compliant GeoPackages
- What changes need to be made to the GeoPackage implementation standard to improve interoperability
- What testing methods are needed to ensure interoperability

2. References

2.1 Normative References

The following normative documents contain provisions that, through reference in this text, constitute provisions of this document. For versioned references, subsequent amendments to, or revisions of, any of these publications do not apply. For unversioned references, the latest edition of the normative document referred to applies.

OGC 06-121r9, *OGC Web Service Common Implementation Specification*, Version 2.0.0, 2010.

OGC 07-057r7, *OpenGIS Web Map Tile Service Implementation Standard*, Version 1.0.0, 2010.

OGC 12-128r10, *OGC® GeoPackage Encoding Standard*, Version 1.0, 2013.

2.2 Informative References

The following informative documents are referenced by this document but do not constitute provisions of this document. For dated references, subsequent amendments to, or revisions of, any of these publications do not apply. For undated references, the latest edition of the normative document referred to applies.

National System for Geospatial-Intelligence (NSG) GeoPackage Encoding Standard 1.0 Implementation Interoperability Standard (DRAFT), 2015.

3. Terms and Definitions

This document uses the terms defined in Sub-clause 5.3 of [OGC 06-121r9], which is based on the ISO/IEC Directives, Part 2, Rules for the structure and drafting of

International Standards. In particular, the word “shall” (not “must”) is the verb form used to indicate a requirement to be strictly followed to conform to this standard.

For the purposes of this document, the following additional terms and definitions apply.

DARPA
Defense Advanced Research Projects Agency

ERDC
U.S. Army Corps of Engineers, Engineer Research and Development Center

ETS
Executable Test Suite

GPKG
GeoPackage

Plugfest
A Plugfest is an event where vendors cooperatively test (and possibly refine) their OGC-based products in a hands-on engineering setting. Plugfests are used to (1) assess the degree to which different products in the marketplace interoperate together based on their implementation of OGC standards, and (2) advance the interoperability of geospatial products and services based on OGC standards in general or within specific communities.

RGi
Reinventing Geospatial Inc., a contractor to the U.S. Army Corps of Engineers

SQL
Structured Query Language

SQLite
A software library that implements a self-contained, serverless, zero-configuration, transactional SQL database engine.

XML
Extensible Markup Language

4. Plugfest Results

The GeoPackage Plugfest participants performed a series of interoperability experiments. The goal of these sessions was to test OGC GeoPackages submitted to the Plugfest to determine if they comply with the OGC GeoPackage encoding standard and are interoperable across several software platforms. Compliance testing was performed using an executable test suite (ETS) built by RGi.

Following are the details of the four items identified in the scope.

- Whether providers produce compliant GeoPackages containing tiled raster data

Success. Providers were generally able to produce GeoPackages that came close to standard compliance. The compliance issues that we observed were typically minor and did not appear to pose a threat to interoperability.

- Whether clients behave as expected after loading compliant GeoPackages

Issue. Compliant GeoPackages were not necessarily interoperable. There were numerous instances of tiles not displaying as expected in integrated clients. We believe this may be due to confusion regarding how tiles are to be indexed. The GeoPackages assessed for the Plugfest were generally created in two steps: 1) native imagery is tiled as JPEG or PNG images and structured as tile pyramids such as those defined for Tile Map Service (TMS) or Web Map Tile Service (WMTS) and 2) these tile structures are then re-indexed to meet the requirements of the GeoPackage standard. GeoPackage producers must first establish the tile origin (i.e. upper left vs. lower left) of the initial tile structure and then may need to correctly translate from globally referenced, absolute tile index numbers (e.g. TMS) to the GeoPackage tile index numbers which are referenced relative to the data bounding box and which restart at zero for each zoom level.

- What changes need to be made to the GeoPackage implementation standard to improve interoperability

Suggested Changes. To mitigate future GeoPackage interoperability issues we believe that implementation profiles should be created to ensure that GeoPackages serve their purpose and are fit for intended use. Implementation profiles should align to specific tile scale sets. For example, a Web Mercator profile would be used with the GoogleMapsCompatible (urn:ogc:def:wkss:OGC:1.0:GoogleMapsCompatible) tile scale set (see Appendix E.4 of [OGC 07-057r7]) [1].

An implementation profile should include, but not necessarily be limited to, the following:

1. Supported Spatial Reference System(s)
2. Tile sizes
3. Zoom levels (names and meters/pixel)
4. Tile pyramid design (including indexing scheme)
5. Tile alignment
6. Tile matrix extent

- What testing methods are needed to ensure interoperability

Not successful. This item is unresolved as we were unable to attain substantial interoperability between implementations.

[1] A National System for Geospatial-Intelligence (NSG) implementation profile is currently being developed under a separate initiative.

We believe that another interoperability experiment should be performed, ideally in conjunction with the development of one or more implementation profiles. Contributors to the U.S. National System for Geospatial-Intelligence (NSG) are currently developing a GPKG implementation profile. We encourage NSG developers (and any other communities of interest that develop an implementation profile) to conduct interoperability experiments as their profile is advanced.

Developers may refer to the GPKG produced by RGi, which passed all of the Plugfest testing. It is available on the on the OGC Portal[2] along with available tests. Additionally, it has been linked on geopackage.org[3].

[2] https://portal.opengeospatial.org/files/?artifact_id=60628

[3] http://www.geopackage.org/#sampledata

Annex A – Experiments

This section documents the details of the two interoperability experiments that were performed.

Note that since this plugfest did not attain the desired results, we will not publish the identities of the GeoPackage providers (other than RGi as mentioned above). We see no benefit to identifying these organizations when the lack of desired interoperability is directly attributable to the standard itself.

A.1 Experiment 1

The GeoPackage Plugfest Working Group performed interoperability testing on 14 and 17 November 2014. Eight GeoPackages containing raster tile data were provided to the working group for testing. As summarized in Table 1, the following tests were conducted:

1. Inspect the GPKG in a SQLite viewer
2. Load the GPKG in DARPA TransApp Panthr Tiles v4.8.2.5
3. Inspect the available zoom levels in Panthr Tiles
4. Perform GeoLocation in Panthr Tiles
5. Load the GPKG in Nett Warrior 2.0.6.x
6. Load the GPKG in ERDC GPKG Viewer vx.x.x
7. Perform GeoLocation in the ERDC GPKG Viewer
8. Test the GPKG using v1.0 of the ETS

Table 1 – Test Results in Experiment 1

T#\GPKG #	1	2	3	4	5	6	7	8	Summary[4]
1	P	P	P	F[5]	P	P	P	P	1/0/7
2	P	PF	P		PF	F	F	F	3/2/2
3	P	P	P		P	F	P	P	2/0/5
4	P	PF[6]	P		PF	F	F	F	3/2/2
5	PF	PF	P		F	F	F	F	3/2/1
6	F	PF	P		P	F	F	F	4/1/2
7	F	P	P		PF	F	F	F	4/1/2
8	PF	PF	P		PF	PF	PF	PF	1/6/1
Summary[3]	2/2/4	0/3/5	0/0/8	1/0/0	1/4/3	6/1/1	5/1/2	5/1/2	

4 Failures / Partial Failures / Passes

[5] This GPKG did not have any tiled data and therefore was not tested further.

[6] In some cases the Geolocation appears to be displaced 1km to the West. The reason for this was not clear.

As presented in Table 2, seven of the eight (87.5%) GeoPackages violated one or more of the requirements in the OGC GeoPackage specification. Only one provider passed all tests but four providers passed at least some of the tests. Most of the standard requirements that were violated were relatively minor and should not affect interoperability, but larger issues remain in determining how the bounding box is used and in standardizing the tile-indexing scheme.

Table 2 – Executable Test Suite Failures in Experiment 1

Requirement	# of Failures	Summary	Implications
2	3	Application ID not set	Minor
5	1	Data type of TEXT(1) not allowed	Minor
11	4	No default SRS values of -1 and 0	Minor
13	3	Last changed column type	Minor
13	1	Column default of '' instead of ""	Minor
15	2	Dates need three-digit milliseconds	Minor
34	1	Must be powers-of-two zoom	Moderate -- may lead to misaligned tiles

In addition, defects were discovered in the client applications. These were reported to the vendors.

A.2 Experiment 2

After reporting the results of Experiment 1, the GeoPackage Plugfest Working Group requested that the original eight data providers produce updated GeoPackages to address requirement failures. Three of the data providers responded to this data call, and the GeoPackage Plugfest participants performed a second round of interoperability testing on 23 January 2015. The following tests were conducted:

1. Inspect the GPKG in a SQLite viewer
2. Load the GPKG in DARPA TransApp Panthr Tiles v4.8.2.5
3. Inspect the available zoom levels in Panthr Tiles
4. Perform GeoLocation in Panthr Tiles
5. Load the GPKG in Nett Warrior 2.0.6.x
6. Load the GPKG in ERDC GPKG Viewer vx.x.x
7. Perform GeoLocation in the ERDC GPKG Viewer
8. Test the GPKG using v1.1 of the ETS

Three GeoPackages containing raster tile data were provided to the working group for testing. These were tested as summarized in Table 3 and Table 4. None of the updated GeoPackages passed all tests. All of these GeoPackages are very close to meeting the OGC GeoPackage Standard, thus the major interoperability problem continues to be inconsistencies in how the tile pyramids are indexed.

Table 3 – Test Failures in Experiment 2

Test	Failures / Partial Failures / Passes	Summary
1	0/0/3	
2	1/2/0	One GPKG did not open, other two had tile offsets
3	2/0/1	
4	3/0/0	
5	1/2/0	One GPKG did not open, other two had tile offsets
6	1/2/0	One GPKG did not open, other two had tile offsets
7	3/0/0	
8	See below	See below

Table 4 – Executable Test Suite Failures in Experiment 2

Requirement	# of Failures	Summary	Implications
13	3	"A GeoPackage file SHALL include a gpkg_contents table per clause 1.1.3.1.1, Table 4 and Table 21." **Required column last_change is defined as:** *Type: DATETIME, not null: true, default value: strftime('%Y-%m-%dT%H:%M:%fZ',CURRENT_TIMESTAMP), primary key: false, unique: false* **but should be:** *Type: DATETIME, not null: true, default value: \s*strftime\s*\(\s*['"]%Y-%m-%dT%H:%M:%fZ['"]\s*,\s*['"]now['"]\s*\)\s*, primary key: false, unique: false*	Moderate -- *this is a change made to the original OGC spec
14	1 (warning)	"The table_name column value in a gpkg_contents table row SHALL contain the name of a SQLite table or view." The table_name value in gpkg_contents table is invalid for the table: water	Minor
60	1	"A GeoPackage MAY contain a table or updateable view named gpkg_data_column_constraints. If present it SHALL be defined per clause 2.3.3.1.1 Table 12 and Table 32. " Required column: gpkg_data_column_constraints.maxIsInclusive is missing	Moderate
82	1 (warning)	"Each extension_name column value in a gpkg_extensions row SHALL be a unique case sensitive value of the form <author>_<extension_name> where <author> indicates the person or organization that developed	Minor

		and maintains the extension. The valid character set for <author> SHALL be [a-zA-Z0-9]. The valid character set for <extension_name > SHALL be [a-zA-Z0-9_]. An extension_name for the ?gpkg? author name SHALL be one of those defined in this encoding standard or in an OGC Best Practices Document that extends it." The following extension_name(s) are invalid:" "	
83	1 (warning)	"The definition column value in a gpkg_extensions row SHALL contain or reference the text that results from documenting an extension by filling out the GeoPackage Extension Template in GeoPackage Extension Template (Normative)." The following table_name values in gpkg_extension table have invalid values for the definition column: Water, TractCentroids, Streets, Signposts, Shoreline, RestrictedTurns, Parks, MajorRoads, Hospitals, Highways, FireStations.	Minor

Annex B: Revision History

Date	Version	Editor	Description
Nov 2014	0.0.1	Jeff Yutzler	First round of experiment
2 Feb 15	0.0.2	Micah Brachman	Second round of experiment
19 Feb 15	0.0.3	Jeff Yutzler	Conclusions
23 Feb 15	0.0.4	Micah Brachman	Review
23 Feb 15	0.0.5	Jeff Yutzler	Review
4 Mar 15	0.0.6	Jeff Yutzler	Finishing
5 Mar 15	0.0.7	Lew Leinenweber	Review
9 Mar 15	0.0.8	Jeff Yutzler	Resolving comments
12 May 15	0.0.9	Jeff Yutzler	Resolving comments
08 June 15	N.A.	Carl Reed	Edits for Publication